

An Essay
on
The Circulation,
Respectfully Submitted to the
Faculty,
of the
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of
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By,

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Since the discovery by the illustrious Harvey of the circulation and the movements of the heart the subject has been one of absorbing interest and universal discussion. The student is struck with the number and diversity of theories advanced by different speculators on this one subject.

In offering a few thoughts myself I shall divide the subject into

- I The Foetal Circulation
- II The transition changes from Foetal to Adult Circulation
- III The Mechanism and forces acting to maintain a healthy circulation

First. In taking a general view of the foetal circulation, we observe several peculiarities in the vascular structure.

1 A communication between the auricles of the heart, by means of the foramen ovale; 2 A communication between the pulmonary artery and the descending aorta, by means of the ductus arteriosus; 3 The internal iliacs under the names of hypogastric, and umbilical arteries are continued to the placenta; 4 A communication in the venous system, between the umbilical vein and the inferior cava, by means of the ductus venosus.

In the early weeks of utero gestation what is termed the vascular area makes its appearance in the embryonic mass, and nucleated corpuscles here begin

to form, and push themselves out into the surrounding tissue, seeming to exhibit an affinity for the parts of the mass to which they are tending.

By this means a canal is, as it were constructed through the different portions of the mass, and filled up with these corpuscles or cells, whose extremities adhere: the intervening cell walls become broken down, and a communication is established from cell ^{to cell}, thus forming a continuous tube or vessel. Such are the primary arteries. By the same process capillaries, and veins are formed: and from the nuclei of the cells which formed the blood vessels, the primary blood corpuscles are formed, and

there circulate through the vessels so constructed. The heart first appears as a simple cavity in a mass of cells, the cavity being formed by the removal of the cells from the center of the mass, and at this early period of its formation contractions may be observed to take place.

Soon however its cavity divides into three compartments, - an auricle, a ventricle, and the artinal bulb; the arterial and venous connections become established, and the heart now bears the form of that of the fish.

As early as the fourth week a septum begins to form in the ventricle, and is completed at the eighth week. The auricular septum remains

imperfect, but the heart may be considered as having four cavities, and as performing its office in the circulatory apparatus.

Without entering into a detail of the various steps in the formation and completion of the ramifying bloodvessels, or of the placenta and its connections with the foetus, we will pass to consider the course and distribution of the blood, to the system of the foetus.

The pure blood is brought from the placenta by the umbilical vein, which passing through the umbilicus enters the liver, where it divides into the following branches. Two or three distributed to the left

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lobe, one which communicates with
the portal vein and supplies the
right lobe, and the ductus venosus
which passes directly backward
to join the inferior cavea. Thus
the liver is supplied with pure
blood in large quantities, which
fact will account for its greater
development at birth.

Through the ductus venosus
the blood flows into the inferior cavea,
and is there mixed with the
impure blood returning from the
lower extremities and abdominal
viscera; passing onward into the
right auricle. It is by means of the
eustachian valve, carried through
the foramen ovale into the left auricle,

From the left auricle it passes into the left ventricle, and from thence is forced into the aorta, and distributed to the head and upper extremities, by the carotid and subclavian arteries. Returning through the superior cave to the right auricle, it passes into the right ventricle, and is propelled from thence into the pulmonary artery. In the adult it would now be conveyed to the lungs for purgification, but these are nearly infusions and but a small portion is taken to them for the purpose of nutrition, while the greater part passes through the ductus arteriosus into the descending aorta, where

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It mingles with that portion of the pure blood, which was not conveyed to the head and upper extremities, and passing through the abdominal aorta, a small portion is distributed to the lower extremities by the external iliacs while the greater part is returned by the hypogastric, and umbilical arteries to the placenta. Here by a wise provision of nature a large amount of blood is conveyed to the head and upper extremities, providing for their necessary nourishment; while the lower extremities are supplied with but a small portion of impure blood. Thus retarding their greater development, that the organs necessary to an independent

ent existence, may be the better provided for. In the placenta, the blood receives a fresh supply of oxygen from the coecal extremities, and ramifying trunks of the uterine blood vessels, and to them it gives up its carbonic acid, by a process of osmosis similar to that carried on in the gill of the fish. Materials for nutrition are also taken up in the same manner, or, by a process of formation of cells which imbibe the nutritious materials, and rupturing liberate their contents in the foetal vessels. An interesting field for investigation here opens to the inquirer, in determining the method, by which the foetus is nourished in utero.

Second. At birth certain changes take place in the mechanism, as well as the course, and distribution, of the blood of the foetus.

With the first inspiration of atmosphere the lung are filled and expanded, and the carbonized blood rushes in to meet the oxygen of the lungs, instead of passing as before through the ductus arteriosus. The communicating duct is of no farther use, and soon shrinks to a mere cord.

The blood having been purified in the lungs, finds its way back to the left auricle through the pulmonary veins, which till now have performed but a small part in the formation of the circulation.

Given on from the left cavities of
 the heart into the aorta, a part
 is distributed to the upper, and a part
 to the lower extremities, passing
 through the external iliacs, while
 the blood already arterialized,
 having no affinity for the oxygen
 contained in the mother's blood, or
 having no need of farther purifi-
 cation, ceases to pass into the hypo-
 gastric arteries and these too,
 become useless as a part of the
 circulatory apparatus, and nature
 converts them into ligaments to
 the bladder.

The blood returning from the
 lower extremities passes along the
 ascending aorta, receiving in its

course, the now impure blood flows
 the portal system through the hepatic
 veins, leaving the ductus venosus
 as the round ligament of the liver.
 Passing on to the right auricle, it there
 meets with blood equally as impure,
 returning from the head and upper
 extremities; and being no longer fitted to
 nourish the system, passes through the
 right ventricle and pulmonary arteries,
 to the lungs where it is again
 purified, and prepared to perform
 another circuit of the system.

The foramen only remains to be
 closed up, which is done by a mem-
 branous layer stretching across it,
 and the metamorphosis from foetal, to
 adult circulation is complete.

Third. The mechanism and forces of which we shall speak, as acting to maintain a free and healthy circulation comprise under Mechanism. The heart, arteries, capillaries, and veins.

The heart, situated in the middle mediastinum is composed of four cavities, right and left auricles, right and left ventricles, The right cavities contain venous, the left arterial blood. The substance of the heart is of a dense muscular fibre, disposed in a circular direction around the cavities, and attached to the fibrous rings, surrounding the greater openings. The heart is surrounded by a shut sac, the

pericardium, which is composed of two layers an external fibrous, and an internal serous, which is reflected and covers the external surface of the heart.

The heart is lined internally with a serous membrane, the endocardium, an extension of which forms the lining membrane of all the blood vessels. The structure of the conduction presents several peculiarities.

The auricles are divided into a principal cavity or sinus, and an appendix auricular, in the latter are found fleshy columns arranged parallel, and hence called *Musculi pectinati*. Into the sinus of the right auricle open the venae cavae ascendens, and descendens, which return the

impure blood from all parts of the body,
 - the coronary vein, which returns
 the venous blood from the structure
 of the heart itself, its opening being
 guarded by the coronary valve; and
 the foramina Thebesii, minute pore
 like openings into all the cavities,
 through which venous blood
 transudes directly, without entering
 the current of the circulation.

In the right auricle are also found
 the Eustachian valve, fossa ovalis,
 and annulus ovalis, relics of the
 fetal structure, together with the
 tuberculum Loweii, a simple
 projection into its cavity, between
 the openings of the cavæ.

Communicating with the right

ventricle, & the auriculo-ventricular opening, surrounded by a dense fibrous ring and guarded by the tricuspid valve, to which are attached the chordal tendinae, tendons of thick fleshy columns, the columnar carinae, for the purpose of strengthening and sustaining the valves in their position.

From the right ventricle opens the pulmonary artery, to convey the blood to the lungs, the mouth of which is guarded by the semilunar valve, to prevent regurgitation.

Into the left auricle open the four pulmonary veins, returning the pure blood from the lungs. Communicating with the ventricle is the auriculo-ventricular opening, smaller than that

in the right cavities, and guarded by the mitral valves, two in number, which are strengthened by cords and muscular columns, like the tricuspid. Opening from the left Atricle is the aorta, which receives the pure blood from the heart, and distributes it to all parts of the body.

The mouth of the aorta is guarded by the semilunar valves, like those at the mouth of the pulmonary artery.

The arteries are composed of three coats, an external cellular, middle muscular, and an internal serous, and are elastic to a considerable degree, allowing themselves to be distended by the im-

pulse of the heart, and contracting again immediately that impulse ceases.

The arteries terminate in the capillaries, which appear like bifurcations of the arteries, though each is as large as the radicle artery from which it springs.

These capillaries again terminate in the radicles of the Veins, which like the arteries are composed of three coats, though they are much thinner and are supplied with valves, to prevent the reflux of blood. The veins also are somewhat elastic, or distensible, and return the blood from the capillaries, to the right auricle.

Force. Under this head we shall consider; The action of the heart, Affinity, Capillary attraction, Siphonic action, Muscular contraction, Erection power of the thorax.

To the action of the heart we shall assign only a sufficient force, by its contractions, to force the blood through the arteries to their capillary terminations, and this it does by spontaneous contractions.

What causes the heart to contract, is a question which cannot be answered with certainty, nor will my limits allow me to discuss it here. We only know that at an early period of fetal life,

while the heart is yet an agglomeration of cells, there exist rhythmical contractions, and we may infer that nature has endowed this organ with rhythmical motions, as a characteristic function.

Certainly no one would attempt to explain, why muscular tissue is more highly endowed with spontaneous contractility, than is yellow elastic tissue; nor do I deem that any multiplication of theories, will be more successful in explaining this phenomenon.

Affinity.* Existing with the earliest formation of blood corpuscles, we notice that there seems to exist some affinity

* For the thoughts here presented on affinity, I am indebted to an excellent work on Physiology, by Dr. Drafus, of New York.

between those corpuscles, and the tissues to be nourished by them. The nuclei of those cells, whose walls form the primary blood vessels, constituting the primary blood corpuscles, circulate through those vessels with an other force to propel them, than what we shall term vital affinity.

By vital affinity we mean, that the circulating fluid contains certain elements, adapted to the accomplishment of certain vital changes in the organic tissues, and that these tissues attract to themselves, fluids bearing such a relation.

If two liquids be allowed to communicate in a capillary tube, the one having a greater affinity for the

Substance of the tube than the other, movements of the liquids will ensue; the one having the greater affinity will be attracted to, and fill the tube, even to the expulsion of the other.

So also with what is termed osmosis: a membrane being interposed between two fluids of different densities, the one having the greater affinity for the substance of the membrane, occupies its pores and repels the other.

In applying this principle to the circulation, we may commence with the simple cell, made up of the cell wall, the contained fluid, and the nucleus. This fluid under the microscope, is observed to pass in distinct currents to the nucleus,

with which it comes in contact, gives up the nutrient elements, and passes on to give place to other portions of the fluid. The same process takes place in the vegetable cell, the nourishment being transmitted through the cell wall to the fluid, from the fluid to the nucleus.

The blood corpuscles only serve the purpose of carriers to the nutrient elements, and hence, having been driven by the heart's action to the systemic capillaries, they appear there laden with oxygen, and a variety of nutrient elements for the reparation of the various tissues, as well as certain effete matters, to be eliminated by excreting organs.

The oxygen has a high affinity for the disintegrating tissue, and is attracted to it: a union takes place and carbonic acid is the result, while in the tissue an affinity is produced for the elements of nutrition, which they absorb and this portion of the blood having lost its affinity for the tissue, is pressed onward into the veins by the approach of other portions of arterial blood.

In like manner blood containing effete matter, as for instance uric acid, has a ~~low~~^{high} affinity for the kidneys, is attracted to them, gives up its urine to the malpighian bodies, and at the same time losing its affinity, is pushed onward to give place

to the constantly approaching masses. The principle or force, of capillary attraction is here made available, in aiding the onward flow of the blood through the smaller veins.

The blood is also aided in its return to the heart, by the syphonic action of the blood vessels, starting from the arch of the aorta, and passing through the upper one half of the body, back to the right auricle, and allowing the whole distribution of vessels, to be represented by a single tube or vessel, we have a simple syphon, whose discharging extremity is some inches lower than its origin. Again, passing from the aorta's arch

through the lower one half of the body,
to the right auricle, we have in the
same manner an inserted siphon,
whose mouth is some inches higher
than its discharging extremity.

The resultant action is the same in
both, and tends powerfully to facil-
itate the return of the venous blood,
to the right auricle.

I can but think, that a little
importance is attached to this, as an
auxiliary force in the circulation.

That the introduction of air into
the veins, during surgical operations
is followed by instantaneous death,
on its arrival at the heart, none
will dispute: Why it is so can
only be explained, by considering it

as an interruption to the syphonic action of the vessels.

In the larger venous trunks lying contiguous to muscles, another auxiliary force is brought to bear on the flow of blood towards the heart. When a muscle contracts longitudinally it expands laterally, and the yielding walls of the veins are pressed upon to such an extent, as to drive the blood from that portion of the tube; the valves prevent it from retrograding, and it is forced onward towards the heart; being retained thereby valves, when the muscle relaxes, the space can only be filled, by blood from the distal portion of the vein.

The Suction power of the Thorax is exerted principally upon the venae cavae. When the sternal ends of the ribs are elevated by the inspiratory muscles, and the diaphragm is contracted, enlarging to so great a degree the thoracic cavity, a vacuum is produced. We are reminded at each inhalation of the great suction power exerted on the trachea, to draw in the atmospheric air as one means of filling this vacuum, and there is no reason why this same suction power should not, to the same extent, be exerted on the trunks of the caeal as they enter the Thorax, tending very forcibly to draw their fluid contents into the thoracic cavity.

In the pulmonic circulation the force of vital affinity is especially manifest. The venous blood burdened with carbonic acid, has a high affinity for the oxygen of the lungs, and is strongly attracted to them; an interchange of gases takes place, the affinity is lost, and the approaching venous blood drives it on into the pulmonary veins, and so back to the left cavities of the heart.

The beauty of this theory, and its aptness to explain so many heretofore unexplained phenomena in nature, recommend it to every thinking mind. A more perfect presentation of this theory, may be found in the pages of Draper's Physiology.

If in the foregoing pages I may seem to have been guilty of plagiarism, the only plea I can urge is, that with the ground so thoroughly canvassed before me, I find it difficult to consider the subject, without making use of ideas advanced by others to some extent.

I may at least congratulate myself, that though I add nothing to science, I have at least familiarized myself, with some of the past, as well as present theories, on this subject.

Very Respectfully.

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